

Application No. 09/359,648  
Docket No. 29250-000253/US

**IN THE CLAIMS**

This is a complete and current listing of the claims, marked with status identifiers in parentheses. The following listing of claims will replace all prior versions and listings of claims in the application.

1. (Previously Presented) A method of predicting the location of a CDMA mobile communications unit in a wireless communications service area, comprising the steps of:

(a) receiving measure attribute information from a mobile unit location in the service area, said attribute information being specific to the location of the mobile unit in the service area;

(b) computing the probability of the mobile unit being at a specific location in the service area in response to said received attribute information using a likelihood probability function, said likelihood probability function having an iterative procedure for generating a maximum likelihood estimator of the mobile unit's location in this service area, wherein said likelihood probability function includes a frequentist likelihood function;

(c) generating an output indicative of the likelihood of the mobile unit being at said location in the service area.

2. (Cancelled)

3. (Previously Presented) A method according to claim 1 wherein the maximum likelihood estimator comprises the coordinates in the service area which maximizes the likelihood probability function.

Application No. 09/359,648  
Docket No. 29250-000253/US

4. (Cancelled)

5. (Previously Presented) A method of predicting the location of a CDMA mobile communications unit in a wireless communications service area, comprising the steps of:

(a) receiving measured attribute information from a mobile unit location in the service area, said attribute information being specific to the location of the mobile unit in the service area;

(b) computing the probability of the mobile unit being at a specific location in the service area in response to said received attribute information using a likelihood probability function;

(c) generating an output indicative of the likelihood of the mobile unit being at said location in the service area;

wherein said likelihood probability function includes an iterative procedure for producing a maximum likelihood estimator of the mobile unit's location in this service area wherein said likelihood probability function comprises a Bayes-modified likelihood function.

6. (Previously Presented) A method according to claim 1 wherein said procedure comprises sequential Bayesian procedure characteristics.

7. (Previously Presented) A method according to claim 6 wherein said sequential Bayesian procedure characteristics are implemented as a frequentist likelihood function.

8. (cancelled)

9. (Original) A method according to claim 1 wherein said attribute information comprises a pilot signal strength measurement of at least one visible pilot signal at said location of the mobile unit.

10. (Original) A method according to claim 9 and additionally including a step (d) prior to step (b) of reducing the effective size of the service area so as to reduce the number of computations required in step (b).

11. (Original) A method according to claim 9 and following step (a) and before step (b), additionally including a step (d) of identifying a region A of support for the mobile unit in the

Application No. 09/359,648  
Docket No. 29250-000253/US

service area and (e) identifying a set of possible pilot signals which can be detected by the mobile unit in said region of support.

12. (Original) A method according to claim 11 and additionally including a step (f) of computing an approximation  $\bar{\theta}_{ij}(x, y)$  of the probability the mobile unit detects a pilot signal at said specific location  $(x, y)$  in said region A for all pilot signals in said set of possible pilot signals and where j is a sector of a multi-sector based station I in said region of support.

13. (Original) A method according to claim 12 wherein  $\bar{\theta}_{ij}(x, y)$  is derived from an RF model for the RF power  $R_{ij}(x, y)$  received by the mobile unit and where the model is of the form of

$$R_{ij}(x, y) = T_{ij} G_{ij}(x, y) L_{ij}(x, y) F_{ij}(x, y) M_{ij}(x, y)$$

where  $T_{ij}$  is the transmit power associated with sector j of base station I,  $G_{ij}(x, y)$  is the antenna gain for the sector j of base station I along the direction pointing towards the location  $(x, y)$  within A,  $L_{ij}(x, y)$  is the distance loss between the base station I associated with the sector j and the location  $(x, y)$  within A,  $F_{ij}(x, y)$  is the shadow fading factor and  $M_{ij}(x, y)$  is the measured noise factor.

14. (Original) A method according to claim 13 wherein said attribute information comprises the measured visibility of a pilot signal transmitted from a base station and the likelihood probability function comprises an iterative frequentist maximum likelihood (ML) function in the form of

$$L_{ML}^i(x, y) \propto L_{ML}^{i-1}(x, y) \prod_{j=1}^K [\bar{\theta}_{ij}(x, y)]^{\mu_i} [1 - \bar{\theta}_{ij}(x, y)]^{1-\mu_i}, \quad (x, y) \in A$$

Application No. 09/359,648  
Docket No. 29250-000253/US

where  $x$  and  $y$  comprise rectilinear coordinates in the service area  $A$ ,  $s$  is the number of measurement epochs, and  $\mu_{ij}^s$  is equal to one or zero depending on whether the mobile unit can detect a pilot signal  $ij$  at measurement epoch  $s$ .

15. (Previously Presented) A method of predicting the location of a CDMA mobile communications unit in a wireless communications service area, comprising the steps of:

(a) receiving measure attribute information from a mobile unit location in the service area, said attribute information being specific to the location of the mobile unit in the service area;

(b) computing the probability of the mobile unit being at a specific location in the service area in response to said received attribute information using a likelihood probability function;

(c) generating an output indicative of the likelihood of the mobile unit being at said location in the service area;

wherein said attribute information comprises a pilot signal strength measurement of at least one visible pilot signal at said location of the mobile unit;

and following step (a) and before step (b), additionally including a step (d) of identifying a region  $A$  of support for the mobile unit in the service area and (e) identifying a set of possible pilot signals which can be detected by the mobile unit in said region of support;

and additionally including a step (f) of computing an approximation  $\tilde{\theta}_j(x, y)$  of the probability the mobile unit detects a pilot signal at said specific location  $(x, y)$  in said region  $A$  for all pilot signals in said set of possible pilot signals and where  $j$  is a sector of a multi-sector based station  $I$  in said region of support;

Application No. 09/359,648  
Docket No. 29250-000253/US

wherein  $\bar{\theta}_{ij}(x, y)$  is derived from an RF model for the RF power  $R_{ij}(x, y)$  received by the mobile unit and where the model is of the form of

$$R_{ij}(x, y) = T_{ij} G_{ij}(x, y) L_{ij}(x, y) F_{ij}(x, y) M_{ij}(x, y)$$

where  $T_{ij}$  is the transmit power associated with sector  $j$  of base station  $I$ ,  $G_{ij}(x, y)$  is the antenna gain for the sector  $j$  of base station  $I$  along the direction pointing towards the location  $(x, y)$  within  $A$ ,  $L_{ij}(x, y)$  is the distance loss between the base station  $I$  associated with the sector  $j$  and the location  $(x, y)$  within  $A$ ,  $F_{ij}(x, y)$  is the shadow fading factor and  $M_{ij}(x, y)$  is the measured noise factor,

wherein said attribute information comprises the measured visibility of a pilot signal transmitted from a base station and the likelihood probability function comprises an iterative Bayes-modified maximum likelihood (ML) estimator in the form of

$$L_{BML}^s(x, y) \propto L_{BML}^{s-1}(x, y) \prod_{i \in K} \frac{[\eta_{ij}^{s-1} + \alpha_{ij}(x, y)]^{\mu_{ij}^s} [s-1 - \eta_{ij}^{s-1} + \beta_{ij}(x, y)]^{1-\mu_{ij}^s}}{\alpha_{ij}(x, y) + \beta_{ij}(x, y) + s-1}, (x, y) \in A$$

where  $x$  and  $y$  comprise rectilinear coordinates in the service area  $A$ ,  $s$  is the number of measurement epochs,  $\eta_{ij}^{s-1}$  is the number of times a pilot signal in section  $j$  of a multi-sector base station  $I$  is visible through the first  $s-1$  measurement epochs,  $\alpha_{ij}(x, y)$  and  $\beta_{ij}(x, y)$  are parameters of a beta distribution, and  $\mu_{ij}^s$  is equal to one or zero depending on whether the mobile unit can detect a pilot signal  $ij$  at measurement epoch  $s$ .

Application No. 09/359,648  
Docket No. 29250-000253/US

16. (Original) A method according to claim 15 where

$$\alpha_y(x, y) = \begin{cases} 1 & , \text{if } \tilde{\theta}_y(x, y) \leq 1/2 \\ \frac{\tilde{\theta}_y(x, y)}{1 - \tilde{\theta}_y(x, y)} & , \text{if } \tilde{\theta}_y(x, y) > 1/2 \end{cases}$$

$$\beta_y(x, y) = \begin{cases} \frac{1 - \tilde{\theta}_y(x, y)}{\tilde{\theta}_y(x, y)} & , \text{if } \tilde{\theta}_y(x, y) \leq 1/2 \\ 1 & , \text{if } \tilde{\theta}_y(x, y) > 1/2. \end{cases}$$

17. (Previously Presented) A method according to claim 14 wherein the frequentist likelihood function  $L_{ML}^i(x, y)$  is combined with a discrete uniform prior distribution for the location of the mobile unit of the form

$$P_{ML}^0(x, y) = \frac{1}{\|A\|}, (x, y) \in A$$

to generate a sequential Bayesian procedure which provides a posterior distribution for the location of the mobile unit of the form

$$P_{ML}^s(x, y) \propto P_{ML}^{s-1}(x, y) \prod_{i=1}^s [\tilde{\theta}_y(x, y)]^{\mu_{ij}^i} [1 - \tilde{\theta}_y(x, y)]^{1 - \mu_{ij}^i}, (x, y) \in A.$$

where  $\|A\|$  is the number of grid points contained within A, and where x and y comprise rectilinear coordinates in the service area A, s is the number of measurement epochs, and  $\mu_{ij}^i$  is equal to one or zero depending on whether the mobile unit can detect a pilot signal ij at measurement epoch s.

Application No. 09/359,648  
Docket No. 29250-000253/US

18. (Previously Presented) A method of predicting the location of a CDMA mobile communications unit in a wireless communications service area, comprising the steps of:

(a) receiving measure attribute information from a mobile unit location in the service area, said attribute information being specific to the location of the mobile unit in the service area;

(b) computing the probability of the mobile unit being at a specific location in the service area in response to said received attribute information using a likelihood probability function;

(c) generating an output indicative of the likelihood of the mobile unit being at said location in the service area;

wherein said attribute information comprises a pilot signal strength measurement of at least one visible pilot signal at said location of the mobile unit;

and following step (a) and before step (b), additionally including a step (d) of identifying a region A of support for the mobile unit in the service area and (e) identifying a set of possible pilot signals which can be detected by the mobile unit in said region of support;

and additionally including a step (f) of computing an approximation  $\tilde{\theta}_j(x, y)$  of the probability the mobile unit detects a pilot signal at said specific location (x,y) in said region A for all pilot signals in said set of possible pilot signals and where j is a sector of a multi-sector based station I in said region of support;

wherein  $\tilde{\theta}_j(x, y)$  is derived from an RF model for the RF power  $R_{ij}(x, y)$  received by the mobile unit and where the model is of the form of

$$R_{ij}(x, y) = T_{ij} G_{ij}(x, y) L_{ij}(x, y) F_{ij}(x, y) M_{ij}(x, y)$$

where  $T_{ij}$  is the transmit power associated with sector j of base station I,  $G_{ij}(x, y)$  is the antenna gain for the sector j of base station I along the direction pointing towards the location (x,y) within A,



Application No. 09/359,648  
Docket No. 29250-000253/US

$L_{ij}(x,y)$  is the distance loss between the base station  $I$  associated with the sector  $j$  and the location  $(x,y)$  within  $A$ ,  $F_{ij}(x,y)$  is the shadow fading factor and  $M_{ij}(x,y)$  is the measured noise factor;

wherein the frequentist likelihood function  $L_{BML}^s(x,y)$  is combined with a discrete uniform prior distribution for the location of the mobile unit of the form

$$P_{BML}^0(x,y) = \frac{1}{\|A\|}, (x,y) \in A$$

to generate a sequential Bayesian procedure which provides a posterior distribution for the location of the mobile unit of the form

$$P_{BML}^s(x,y) \propto P_{BML}^{s-1}(x,y) \prod_{j=1}^K \frac{[n_j^{s-1} + \alpha_j(x,y)]^{\mu_j^s} [s-1-n_j^{s-1} + \beta_j(x,y)]^{1-\mu_j^s}}{\alpha_j(x,y) + \beta_j(x,y) + s-1}, (x,y) \in A.$$

where  $\|A\|$  is the number of grid points contained within  $A$ , and where  $x$  and  $y$  comprise rectilinear coordinates in the service area  $A$ ,  $s$  is the number of measurement epochs,  $n$  is the number of times a pilot signal in section  $j$  of a multi-sector base station  $I$  is visible through the first  $s-1$  measurement epochs,  $\alpha_j(x,y)$  and  $\beta_j(x,y)$  are parameters of a beta distribution, and  $\mu_j^s$  is equal to one or zero depending on whether the mobile unit can detect a pilot signal  $ij$  at measurement epoch  $s$ .

Application No. 09/359,648  
Docket No. 29250-000253/US

19. (Original) A method according to claim 18 where

$$\alpha_y(x,y) = \begin{cases} 1 & , \text{if } \bar{\theta}_y(x,y) \leq 1/2 \\ \frac{\bar{\theta}_y(x,y)}{1 - \bar{\theta}_y(x,y)} & , \text{if } \bar{\theta}_y(x,y) > 1/2 \end{cases}$$

$$\beta_y(x,y) = \begin{cases} \frac{1 - \bar{\theta}_y(x,y)}{\bar{\theta}_y(x,y)} & , \text{if } \bar{\theta}_y(x,y) \leq 1/2 \\ 1 & , \text{if } \bar{\theta}_y(x,y) > 1/2. \end{cases}$$

20. (Currently Amended) Apparatus for estimating the location of a mobile communications unit in the service area of a wireless communications system comprising:

a plurality of base stations and at least one switching center providing a common access to said plurality of base stations;

a computing apparatus including a memory, electrically connected to at least one of said base stations or said switching center, for storing a set of parameters of a model of the wireless communications system including the RF environment and predicted values of attribute measurement of the service area and wherein the values of the parameters are adjusted to obtain a substantial match between measured attribute values at a predetermined number of locations in the service area and the corresponding initial values predicted by the model;

said computing apparatus further ~~including software for~~ calculating, in response to one or more attribute values being measured and reported by the mobile unit from a specific location within the service area, a predicted location of the mobile unit within the service area using a likelihood function, said likelihood probability function having an iterative procedure for producing

Application No. 09/359,648  
Docket No. 29250-000253/US

a maximum likelihood estimator of the mobile unit's location in this service area, wherein said likelihood probability function includes a frequentist likelihood function; and

circuit means coupled to said computing apparatus for generating an output indicative of the predicted location of the mobile unit.